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ORIGINAL ARTICLE

Inverse association between cigarette and water pipe smoking and hypertension in an elderly population in Iran: Bushehr elderly health programme

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The collected data in Bushehr Elderly Health (BEH) Program which had detailed the data on participants' smoking status and habits, was analysed to investigate the association between smoking of both water pipes and cigarettes and hypertension in an elderly population. Three thousand elderly men and women who participated in the baseline assessment of the BEH Program—a prospective population-based study being conducted in Bushehr, Iran—were selected randomly through a multistage, stratified cluster sampling method. Systolic and diastolic blood pressures were measured twice using a mercury sphygmomanometer, and researchers asked participants about medical history of hypertension as well as history of cigarette and water pipe smoking. Researchers used binary logistic regression models to assess the association of hypertension and smoking, and found an inverse, statistically significant association between current smoking and hypertension (odds ratio (OR) = 0.50 (95% confidence interval (CI) = 0.41, 0.60)). The association remained statistically significant after controlling for age, education and body mass index (OR = 0.54 (95% CI = 0.45, 0.66)). Findings were consistent for cigarette and water pipe smoking by sex (all ORs were inverse and statistically significant). Both cigarette and water pipe smoking were associated with reduced hypertension among older people, but the strength of association was different between men and women and also between cigarette and water pipe smoking. The reasons behind the association as well as the differences observed need to be investigated through more comprehensive, longitudinal studies.

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INTRODUCTION

High blood pressure (BP) (that is, hypertension) is one of the leading risk factors for premature mortality and disability worldwide.[1,2] According to the literature, more than 20% of adults worldwide have hypertension, and an estimated 9.4 million deaths occur annually due to hypertension-related complications.[3] Low-income countries have the highest prevalence of hypertension, where many people do not have access to treatment.[4] In 2013, ~22% of deaths in the Middle East and North Africa regions were attributed to hypertension.[4] Hypertension is also considered an outcome of many risk factors, including an unhealthy diet, physical inactivity, tobacco use, alcohol use, obesity and some diseases.[2] The WHO has made the detection, treatment and control of hypertension worldwide an important priority.[3]

About six million deaths each year are attributed to smoking.[5] Globally, there are about one billion smokers, of whom 80% live in low- and middle-income countries.[5] Tobacco smoke contains various types of chemical substances, including nicotine, which is associated with cardiovascular diseases, including coronary heart disease, strokes, aneurysms, peripheral arterial disease and Buerger's disease.[6] Cigarette smoking has adverse effects on many organs.[7] In addition to its role in cardiovascular disease, it has been linked to various types of cancers and respiratory diseases.[7] Although smoking is the most common form of tobacco consumption, the use of water pipes is a prevalent form of tobacco use in many parts of the world, especially Asia, Africa and the Middle East.[8] The highest prevalence of water pipe smoking is in the Eastern Mediterranean region, where the number of young people who smoke water pipes is increasing.[9–11] Although many smokers believe that water pipe smoking is less harmful than smoking cigarettes, or even harmless, studies have shown that water pipe smoking has many detrimental acute and chronic effects on respiratory and cardiovascular systems.[12]

Smoking and hypertension are among the main risk factors for cardiovascular disease, which is the leading cause of death worldwide.[1] However, there is no consensus on the relationship between smoking and the incidence of hypertension, with some studies reporting that smoking was a risk factor for hypertension[13,14] and others, including the Persian Gulf Healthy Heart Study, a population-based, prospective study in Iran, found an inverse association between these factors.[15–17] In addition, this research reported that smoking modified the effects of some other risk factors (for example, diabetes and hyperlipidemia) on hypertension.[17]

The Bushehr Elderly Health programme is a population-based, prospective cohort study currently underway in Bushehr, Iran that

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collects comprehensive data on participants' smoking histories and habits. Using baseline data from the Bushehr Elderly Health programme, we investigated the association of both water pipe smoking and cigarette smoking with hypertension in an elderly population in Iran. To the best of our knowledge, this is the first study to examine the association of both water pipe smoking and cigarette smoking with hypertension.

MATERIALS AND METHODS

The study population consisted of 3000 individuals aged ⩾60 years who were randomly selected using a multistage, stratified cluster sampling method. On the basis of the geographical classifications of the municipality, Bushehr Port was stratified into 75 strata. The number of participants was proportional to the number of households living in each of the 75 strata in Bushehr Port. Details on the methodology of the study have been described elsewhere.[18]

All the participants in the Bushehr Elderly Health programme provided written informed consent, and the study protocol was approved by the Research Ethics Committee of Bushehr University of Medical Sciences (Reference number: B-91–14-2).

A trained nurse measured systolic BP (SBP) and diastolic BP (DBP) using a mercury sphygmomanometer, with a cuff size measuring 12 cm wide and 22 cm long. Each participant's BP was measured after a 15-min rest. BP was measured twice, with a 10-min interval between the two measurements. During the measurements, the participants were in a sitting position, with their left arm resting at heart level and their palm facing upwards. The average of the two measurements was considered the participant's BP.

'Hypertension' was defined as the existence of at least one of three conditions: (a) SBP ⩾ 140 mm Hg; (b) DBP ⩾ 90 mm Hg; or (c) current consumption of anti-hypertensive drugs. 'Smoking' was defined as smoking at least one cigarette or one water pipe per day. 'Current smokers' were defined as those who smoked cigarettes or water pipes regularly at the time of the study. 'Former smokers' were considered those who had quit using cigarettes or water pipes. People who were irregularly smoking (from time to time) and were not smoking every day as a routine were categorized as 'intermittent smokers'. Current, intermittent and former smokers were categorized as 'ever smokers', and 'never smokers' were those who had never smoked in their lives.

Each participant's height was measured using a stadiometer, with a precision of 1 cm. The participant's weight was measured while wearing light clothing and no shoes, using a scales with a precision of 100 g. The body mass index (BMI) was defined as the weight in kilograms divided by height in metres squared. The highest educational level completed by each participant was recorded and classified as either no education, primary school, secondary school, high school or university.

Statistical analysis

The data was described as the prevalence (percentage of those with the phenotype of interest including smoking status, demographic status and so on) for categorical variables and means and s.d. for continuous variables. Between-group differences in the prevalence were compared using Pearson's X^2-test, and the means were compared between groups using an independent sample *t*-test. The normality was checked using inspection of histogram, Q–Q plots and Kolmogorov–Smirnov test before applying independent *t*-test.

Multiple binary logistic regression models were used to investigate the association of hypertension (dichotomous dependent variable) and smoking (independent variable) according to sex and type of smoking, adjusted for potential confounders (that is, age and education). A multinomial smoking variable was entered in the logistic regression model as an indicator variable, and the never smoking group was considered the reference group.

The mediating effect of BMI on the association between smoking and hypertension was investigated by including the BMI as an independent variable in the logistic regression models.

Crude and adjusted odds ratios (ORs) and their 95% confidence intervals were reported as measures of the association. The statistical analyses were performed using the Stata Statistical package (Stata Statistical Software: Release 13; StataCorp, TX, USA). *P*-values < 0.05 were considered statistically significant.

RESULTS

In total, 3000 elderly individuals aged 60 years and older participated in the Bushehr Elderly Health Programme: 1455 (48.5%) men and 1545 (51.5%) women. The average age of the participants was 67.9 ± 7.1 years. Table 1 shows the socio-demographic characteristics and frequency of risk factors of the participants, stratified according to sex.

In the study group, 1874 (62.5%) participants had hypertension. Of those, 1507 (50.2%) had a physician-confirmed diagnosis of hypertension, of whom 1409 (93.5%) were taking anti-hypertensive medicine at the time of the examination. In addition, 1145 (38.2%) participants had SBP ⩾ 140 mm Hg, and 183 (6.1%) had DBP ⩾ 90 mm Hg. The prevalence of hypertension among men was 56.4%, and it was 68.2% among women ($\chi^2(1) = 45.0$, $P < 0.001$). The mean SBP and DBP and corresponding SDs of the men and women were 134.2 ± 18.4 and 135.4 ± 20.2 ($t(2998) = -1.632$, $P = 0.103$)) and 77.0 ± 12.2 and 76.8 ± 8.2 ($t(2998) = 0.489$, $P = 0.652$), respectively.

The frequency of current smokers was 304 (20.9%) for men and 281 (18.2%) for women. For former smokers, the frequencies were 381 (26.2%) for men and 328 (21.2%) for women. For intermittent smokers, the frequencies were 5 (0.3%) for men and 7 (0.5%) for women. The prevalence of smoking among men versus women was statistically significantly different ($\chi^2(3) = 13.4$, $P < 0.001$). Table 1 shows the prevalence of smoking according to sex and type of smoking (that is, cigarette and water pipe).

The results of the binary logistic regression analyses revealed an inverse, statistically significant association between current smoking and hypertension (OR = 0.50 (95% confidence interval = 0.41,

Table 1. Socio-demographic and risk factors of participants; BEH Program

Factor (N (%))	*Men (1455 (48.5))*	*Women (1545 (51.5))*
Age group		
⩽64	616 (42.3)	674 (43.6)
65–69	317 (21.8)	378 (24.5)
70–74	230 (15.8)	200 (12.9)
75–79	166 (11.4)	181 (11.7)
⩾80	126 (8.7)	112 (7.2)
Education		
No education	315 (21.6)	777 (50.3)
Primary school	400 (27.5)	459 (29.7)
Secondary school	276 (19.0)	151 (9.8)
High school	287 (19.7)	125 (8.1)
University	177 (12.2)	33 (2.1)
Smoking[a]		
Water pipe		
Non-smoker	1143 (78.8)	951 (61.4)
Former smoker	198 (13.4)	320 (20.9)
Intermittent smoker	4 (0.3)	7 (0.5)
Current smoker	110 (7.5)	267 (17.2)
Cigarette		
Non-smoker	1023 (70.3)	1522 (98.5)
Former smoker	233 (16.0)	9 (0.6)
Intermittent smoker	1 (0.1)	0 (0.0)
Current smoker	198 (13.6)	14 (0.9)
Hypertension[a]	820 (56.1)	1054 (68.4)
BMI[a,b]		
<25	615 (42.6)	414 (27.8)
25–29.9	612 (42.7)	591 (39.0)
⩾30	211 (14.7)	511 (33.2)

Abbreviations: BEH, Bushehr Elderly Health; BMI, body mass index.
[a]Age-adjusted percentages.
[b]46 missing.

Table 2. Crude and adjusted odds ratio (95% confidence intervals) of the association between smoking (current smokers vs others and ever smokers vs others) and hypertension by sex; BEH Program

		Crude				*Age-, education-adjusted*				*Age-, education- and BMI-adjusted*			
	Smoking status	*Men*	*LL*	*Women*	*LL*	*Men*	*LL*	*Women*	*LL*	*Men*	*LL*	*Women*	*LL*
Cigarette													
	None	Reference	−991.1	Reference	−962.6	Reference	−982.7	Reference	−949.0	Reference	−941.3	Reference	−916.5
	Former	1.17 (0.87–1.56)		1.61 (0.33–7.79)		1.15 (0.86–1.54)		1.55 (0.32–7.58)		1.09 (0.81–1.47)		1.29 (0.26–6.39)	
	Intermittent	1		—		1		—		1		—	
	Current	0.65 (0.48–0.88)		0.26 (0.09–0.77)		0.69 (0.50–0.94)		0.28 (0.09–0.85)		0.81 (0.61–1.16)		0.30 (0.10–0.93)	
Water pipe													
	None	Reference	−985.2	Reference	−954.5	Reference	−975.9	Reference	−941.0	Reference	−933.5	Reference	−909.4
	Former	1.35 (0.99–1.85)		1.33 (1.00–1.78)		1.24 (0.90–1.72)		1.14 (0.85–1.54)		1.23 (0.89–1.72)		1.16 (0.85–1.58)	
	Intermittent	0.76 (0.11–5.38)		0.59 (0.13–2.67)		0.75 (0.10–5.34)		0.58 (0.13–2.64)		0.58 (0.08–4.17)		0.62 (0.14–2.88)	
	Current	0.43 (0.29–0.65)		0.59 (0.45–0.78)		0.41 (0.27–0.62)		0.54 (0.40–0.72)		0.45 (0.29–0.69)		0.56 (0.42–0.75)	
Cigarette	Current/others	0.63 (0.47–0.85)	−992.2	0.26 (0.09–0.77)	−962.7	0.67 (0.42–0.91)	−983.8	0.28 (0.09–0.85)	−949.2	0.83 (0.60–1.14)	−941.8	0.30 (0.10–0.92)	−916.5
Water pipe	Current/others	0.41 (0.28–0.62)	−987.1	0.55 (0.42–0.72)	−956.8	0.40 (0.26–0.60)	−976.9	0.52 (0.40–0.62)	−941.6	0.43 (0.28–0.66)	−934.4	0.54 (0.41–0.82)	−910.0
Smoking	Current/others	0.49 (0.38–0.63)	−981.6	0.52 (0.40–0.68)	−954.3	0.50 (0.39–0.65)	−973.4	0.50 (0.38–0.65)	−939.3	0.60 (0.46–0.78)	−935.5	0.51 (0.39–0.68)	−907.9
Cigarette	Ever/never	0.89 (0.71–1.12)	−996.2	0.50 (0.22–1.15)	−964.6	0.91 (0.72–1.14)	−986.8	0.52 (0.23–1.20)	−950.7	0.97 (0.77–1.22)	−942.4	0.51 (0.22–1.18)	−917.7
Water pipe	Ever/never	0.89 (0.69–1.15)	−996.3	0.89 (0.72–1.11)	−965.3	0.83 (0.64–1.08)	−986.2	0.78 (0.62–0.99)	−949.8	0.85 (0.65–1.11)	−941.7	0.80 (0.63–1.02	−917.2
Smoking	Ever/never	0.81 (0.66–0.99)	−994.7	0.85 (0.68–1.06)	−964.8	0.78 (0.63–0.97)	−984.6	0.75 (0.59–0.94)	−948.8	0.85 (0.68–1.06)	−941.4	0.76 (0.60–0.96)	−916.3

Abbreviations: BEH, Bushehr Elderly Health; BMI, body mass index; LL, Model Log Likelihood.

0.60)). The association remained statistically significant after controlling for age and education (OR = 0.49 (95% confidence interval = 0.41, 0.59)). The association remained statistically significant after controlling for BMI (OR = 0.54 (95% confidence interval = 0.45, 0.66)). As shown in Table 2, these findings remained consistent for cigarette smoking and water pipe smoking, stratified by sex (that is, all ORs were inverse and statistically significant).

Ever-smoking showed an inverse association with hypertension, but this finding was generally not statistically significant in the different sex and smoking status groups (Table 2).

When smoking (that is, cigarette or water pipe) was entered as an indicator variable into the logistic regression model, the results revealed that current smokers showed an inverse, statistically significant association with hypertension, as compared to never smokers (Figure 1).

In addition, there was a direct association between being a former smoker and hypertension and an inverse association between being an intermittent smoker and hypertension. The associations were consistent even after adjustments for age, education and BMI (Figure 1). However, both these associations were statistically nonsignificant.

DISCUSSION

The present study revealed an inverse association between smoking and hypertension among current smokers (cigarette and water pipe). This association remained strong after adjustment for the BMI.

An association between smoking and hypertension has not been clearly demonstrated.[19] Although some studies pointed to a direct association between smoking and hypertension,[20,21] others found no association or an inverse association, like that observed in the present study.[16,19,22,23] The results of a recent systematic review and meta-analysis of 242 studies from around the world showed that the prevalence of hypertension was much lower among smokers compared to nonsmokers in all WHO regions, except South and East Asia.[24] In addition, an observational analysis of a meta-analysis of 23 population-based studies, which included 141 317 participants, showed that being a current smoker was associated with lower SBP and DBP and a lower risk of hypertension.[25] The authors of the study concluded that smoking may increase the risk of cardiovascular diseases by increasing the resting heart rate.

Most of the previous studies that found an inverse association between smoking and hypertension did not elucidate the mechanisms underlying the association. Onat *et al.*[26] asserted that BMI may mediate the effect of smoking on hypertension. They argued that smoking reduced the BMI, which was itself a strong predictor of hypertension. Therefore, they concluded that the inverse association between smoking and hypertension could be partly explained by the mediating effect of obesity. However, our findings do not support this argument, as the inverse association remained after controlling for the effect of BMI.

Other reasons for the inverse association between smoking and hypertension have also been suggested. According to the 'rebound phenomenon', acute exposure to nicotine during smoking leads to a transient increase in BP, which then declines after the removal of this effect.[27,28] Hansen *et al.*[29] described the role of an 'adaptation process' in the inverse association between smoking and hypertension.[30] As part of this process, the body's systems become used to tobacco compounds. In another phenomenon, known as 'masked hypertension', tobacco compounds cause alterations in the arterial wall.[30] However, due to the masking effects of nicotine, the symptoms of hypertension are not manifested for some time, and stable hypertension is detected only after severe structural damage to the arterial wall has occurred.[30,31] Moreover, confounding effects of variables such as

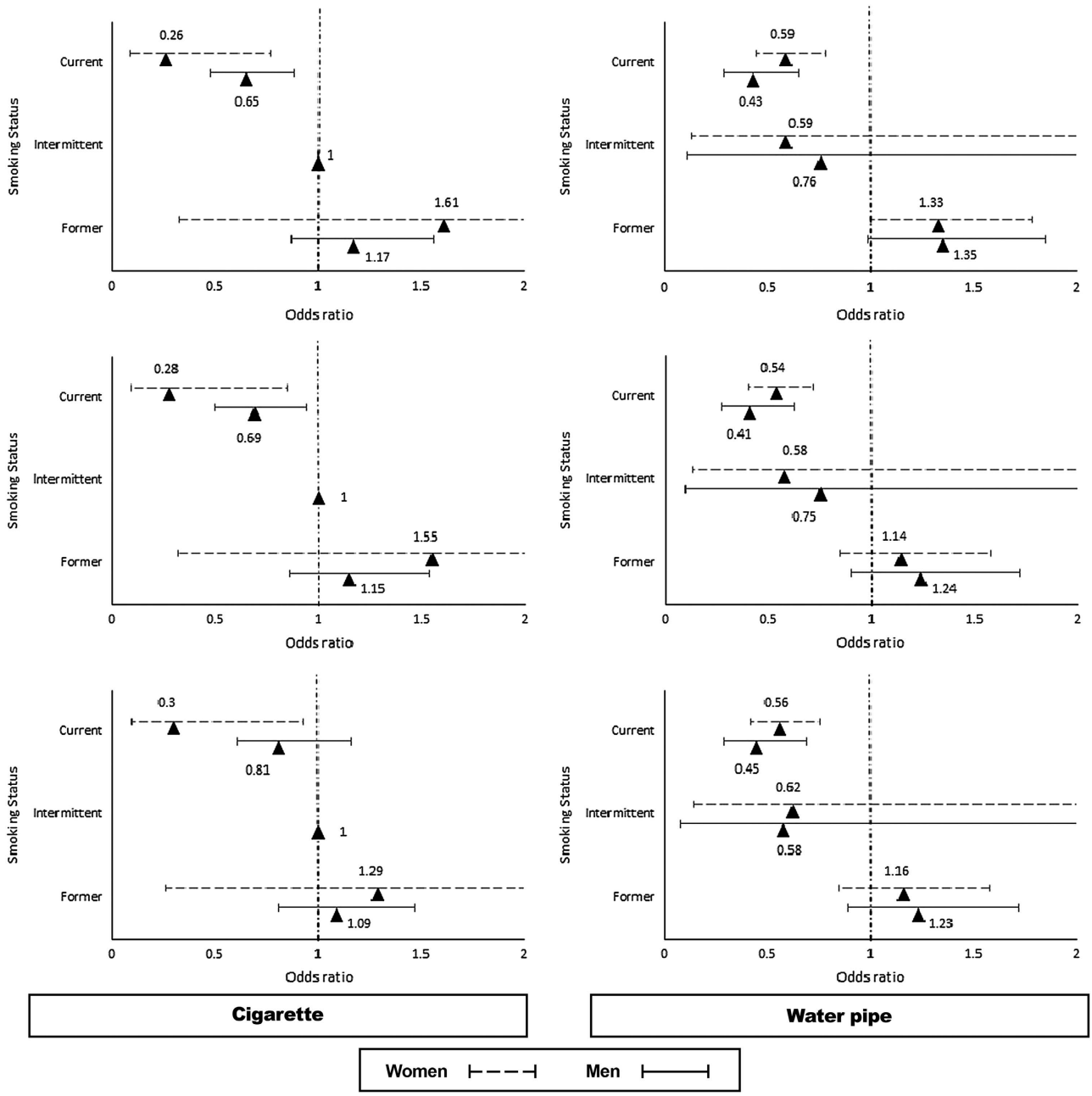

Figure 1. The OR of the association between smoking and hypertension by sex, smoking type and smoking status (top: crude; middle: age-, education-adjusted; bottom: age-, education-, BMI-adjusted ORs); Bushehr Elderly Health Program.

diet or exercise were very unlikely to be influential on the association. We could not find any evidence suggesting that smokers might have healthier lifestyle compared to nonsmokers. In fact, the opposite is more acceptable. Moreover, we found no significant variation for the physical activity between smokers and nonsmokers in our data so it was not included in the analysis.

On the basis of the findings of the present study, while the effects of smoking cigarettes on reducing hypertension were much greater in women than in men, the effects of water pipe smoking on reducing hypertension were greater in men. However, the latter finding was statistically nonsignificant. Virdis *et al.*[21] also reported that the effects of cigarette smoking on hypertension differed in men and women. They suggested that this difference might be due to a complex interaction of smoking, alcohol drinking and BMI rather than a chronic independent effect of smoking alone. In the present study, the difference between the effects of cigarette smoking and water pipe smoking on hypertension existed among men and women, even after adjustment for BMI. The confounding effect of alcohol consumption is not likely to explain the observed difference, as the rate of alcohol consumption is very low among the study population (that is, religious elderly individuals in Iran). On the other hand, we are unable to explain why water pipe smoking and cigarette smoking had different effects on hypertension and why this effect was different between men and women. The interactions of various factors, such as smoking habits (that is, type of smoking, amount and duration of each puff), duration of each session of smoking especially in water pipe smoking and physiological differences between men and women, may have a role in this finding. Further research is needed to shed light on similarities and differences between smoking cigarette and water pipe and

reasons for having different effects on hypertension in men and women.

In the present study, detailed data on both cigarette and water pipe smoking enabled us to investigate the association of both types of smoking with hypertension and compare the results in a large, population-based study. However, as this study was based on a cross-sectional dataset, causal inferences cannot be drawn about the observed associations. For example, they could be due to a survival effect, although there is no evidence to suggest the presence of such an effect. An analysis of prospective data in a follow-up study of the participants might provide deeper insight into the observed associations. We also used a sphygmomanometer with a fixed cuff size to measure BP. This might have induced a measurement error and subsequent non-differential misclassification of hypertension, which could have reduced the strength of the observed associations.

According to the results of this study, both cigarette smoking and water pipe smoking were associated with reduced hypertension among older people. The strength of the association differed between men and women and between cigarette and water pipe smoking. However, it was not possible to quantify the magnitude of exposure or hypertension due to the limitations of the data. The reasons underlying the association, as well as sex differences in the association, need to be investigated in comprehensive, longitudinal studies.

What is known about topic?

- Smoking and hypertension are among the main cardiovascular risk factors.
- Although smoking is expected to lead to the raised blood pressure, available evidence is controversial.

What this study adds?

- This is the first time that the effect of smoking cigarette and water pipe on hypertension has been investigated simultaneously.
- In this study, the association between smoking and hypertension has been investigated in an elderly population.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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